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LOGGING FOR WATER QUALITY IN NORTHERN CALIFORNIA 1/

By
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ABSTRACT: Eleven "do's and don'ts" of logging for preserving water quality are listed and tips for recognizing the more erodible sites are given.

The Geological Survey estimated that 1,285,300 tons of suspended sediment flowed past the Arcata streamgaging station on the Mad River during 1960. If we imagine that this sediment had come from a uniform blanket of soil spread over the whole watershed, it would have amounted to an average soil loss of 0.026 inches. This means an erosion rate far in excess of the average rate of new soil formation, and we would be forced to predict a serious long-term loss in average soil productivity for the whole watershed. But the sediment source was not uniform; there are both areas of negligible erosion and of heavy sediment production. Many of these latter areas are now so completely denuded that they will produce no usable crops in the foreseeable future.

There is also an unfavorable short-term effect of excessive erosion--loss of water quality. People do not like to drink muddy water. Industry cannot use it. Siltation damages salmon spawning grounds and robs reservoirs of expensive, hard-to-replace storage space.

1/ Based on a paper presented at the Redwood Region Logging Conference, Eureka, California, March 8, 1963.

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Rules for Logging

As our population grows, we are becoming increasingly aware of the need to protect water quality. Land managers have developed many important rules for logging while preserving water quality, including these:

1. Plan landings, roads, and skid trails so that they are not in the creekbeds and washes.
2. Install adequate cross-drainage on all temporary roads and skid trails before you move to the next logging area.
3. Remove temporary fills and drainage structures in water channels before you leave a logged area.
4. Keep damaging traffic off unsurfaced roads that are soft.
5. Repair and clean out all drainage ditches, dips, and culverts at least every fall.
6. Compact big fills during road construction.
7. Keep road fills and logging debris out of creeks.
8. Keep bulldozers off steep slopes.
9. Never construct upside-down fills (surface soils and slash underneath and rock on top).
10. See that all permanent roads have adequate drainage for surface and sub-surface water.
11. Use logging systems that minimize soil disturbance and road construction.

As we apply these rules, a critical question is: Where are the tough areas--where does failure to apply these practices lead to the most serious erosion consequences? Every logging show is different. A logging practice which might cause an extreme loss of water quality in one place may cause only slight damage in another. Many other variables besides logging methods and procedures influence the amount of sediment produced by a watershed.

Equation for Watershed Erosion

We can express this same thought in mathematical terms by using an equation, or model, such as:

$$E = f\,(M, T, V, L, G, U \ldots).$$

In this equation, E represents watershed erosion and is regarded as being a function (f) of meteorology (M), terrain (T), vegetation (V), land use and condition (L), susceptibility of soil material to gullying and sheet erosion (G), and slope stability (U).

Research [2/] has shown that by solving statistical equations of this kind the relative amounts of sediment attributable to each cause can be estimated.

2/ Some research studies of this kind have been summarized by Anderson, H. W., and Wallis, J. R., Sediment sources and causes, Pacific Coast Basins in Oregon and California. (Paper presented at Fed. Inter-Agency Conf. on Sedimentation, Jackson, Miss., Jan. 29, 1963.)

Meteorology.--The amount, distribution, intensity, and kind of precipitation can greatly influence sediment production from watersheds. For example, snowstorms produce less sediment than do rainstorms, and the amount of sediment from rainstorms varies with the amount and intensity of rainfall, and with the wetness of the soil mantle when the storm arrives.

Terrain.--Wide variations in suspended sediment production also can be attributed to such terrain variables as steepness of watershed slope and size and shape of the basin.

Vegetation.--Cover density and species composition can influence the suspended sediment production of a watershed in at least four ways. First, the roots of deep-rooted tree and brush species provide mechanical stability for many slopes that would otherwise be unstable. Second, the leaky umbrella formed by leaves, branches, and litter protects the soil from the blows of falling raindrops. Third, the velocity and hence the erosive power of surface runoff water is reduced by dense, low vegetation and surface litter. Fourth, deep-rooted forest and brush species transpire more soil water than do shallow herbs and grasses. This extra drying of the soil may be enough to prevent some incipiently unstable slopes from sliding.

Land use and condition.--In many studies, the variation in land use and condition has accounted for more of the variation in stream sediment loads than have the variables not subject to human control or modification, such as meteorology and terrain. Included in the land-use category are some logging practices, wildfires, most road and freeway construction, mining, overgrazing, and unwise agricultural practices.

Unstable slopes.--Active soil creeping and landslides are prime contributors to the sediment loads of our northern California streams. Many inherently unstable slopes have been set in motion by engineers and loggers who disregarded the warning signs of instability when planning their road and logging layouts. As a result, water quality has suffered. The warning signs are described in a well-illustrated little booklet by Cleaves[3/] and each of them means potential trouble for water quality. Among other signs, Cleaves cites rock strata which parallel the slope, hummocky ground, leaning trees, lines of seep water, and small surface ponds, and all of these are common in northern California.

In addition to these field signposts of slope instability, we have the Soil-Vegetation Survey maps[4/] which are available for most of Humboldt and Mendocino counties. Some symbols on these maps should be

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3/ Cleaves, Arthur B. Landslide investigations. A field handbook for use in highway location and design. U.S. Dept. Commerce, Bur. Public Roads. 67 pp., illus. 1961. Available from Superintendent of Documents, U.S. Govt. Printing Office, Wash. 25, D. C., 30 cents.

4/ Timber Stand Vegetation and Soil-Vegetation Maps and Legends, prepared by the Pacific Southwest Forest and Range Experiment Station in cooperation with the California Division of Forestry, University of California, and California Region, U.S. Forest Service. Available from the Regional Forester, U. S. Forest Service, 630 Sansome St., San Francisco 11, Calif.

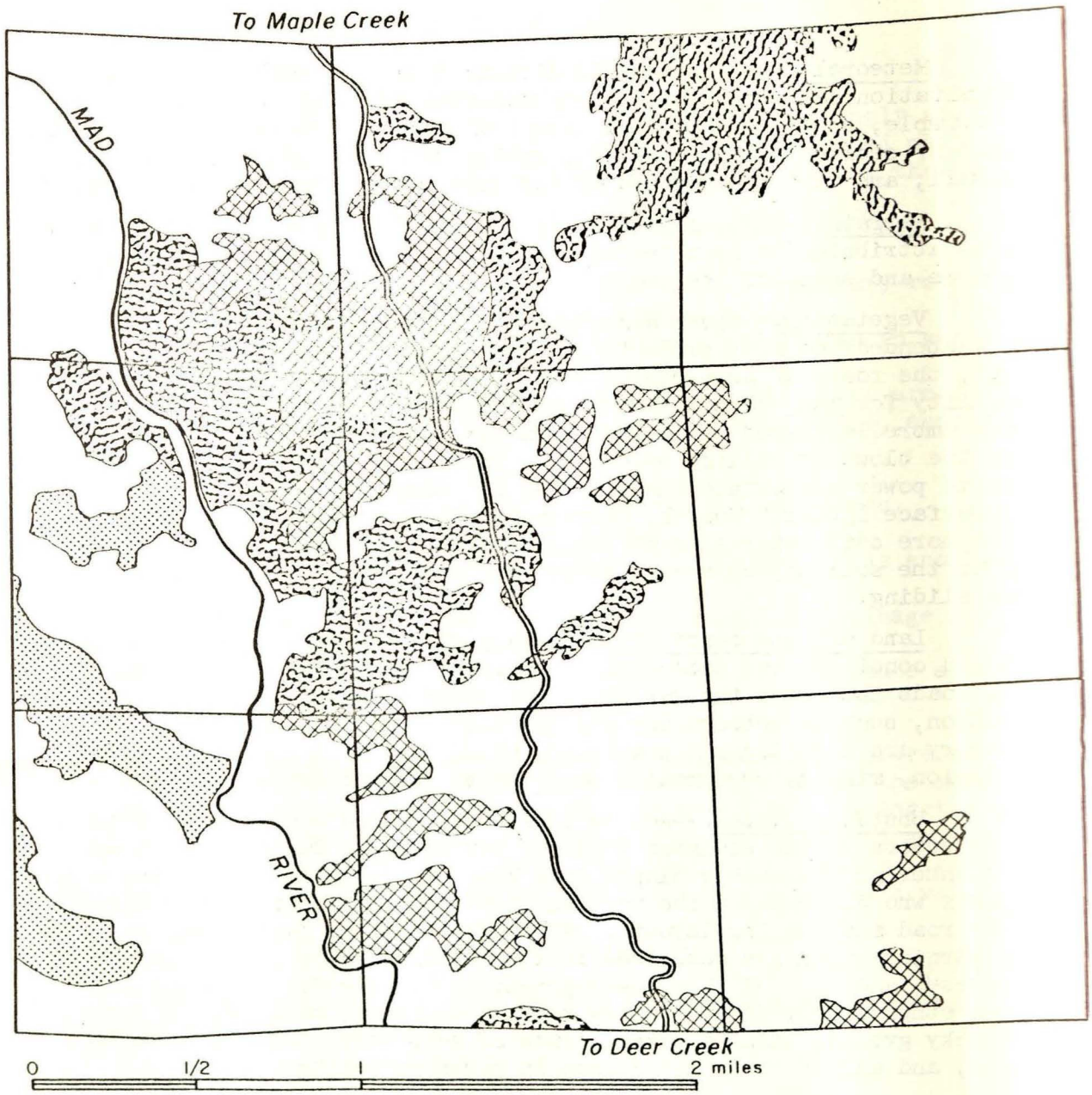

Figure 1.--Slide hazard map adapted from a portion of Soil-Vegetation Survey Map 26C-1.

considered warning signals--telling you not to build roads or yard timber there, unless you are prepared to damage water quality. For example, the symbol $\frac{752}{4S\text{-}3}$ appears on some map sheets. The upper part of this symbol indicates that this is an area of Yorkville soil series. These soils slide even before they have been disturbed, and roads should avoid them whenever and wherever possible. Other slide soils that you should watch out for are: Atwell (823), Zanone (852), and McMahon (839). The lower right hand number of the symbol tells you how steep the ground is--a 1 means less than 30 percent; a 2 means 30-50 percent; a 3 means 50-70 percent and a 4 means more than 70 percent. By arbitrarily combining these slope classes with the known slide-prone soil series, you can make an approximate soil slide-hazard map for any area in which you happen to be interested (fig. 1).

Gullies and sheet erosion.--Sheet erosion and gullying can also contribute much sediment. But here again, not all soils behave alike. Soil erodibility indexes which correlate with measured differences in the susceptibility to erosion have been developed. One such index--surface-aggregation ratio--has been related to nine rock types commonly found in northwest California. From the resulting index numbers, you can get an idea of the relative erodibility, or susceptibility to removal by running water, of the surface layer of soils developed from these various rock classes:

Rock type	Surface-aggregation ratio
Quartz diorite	132.4
Granodiorite	112.2
Cenozoic non-marine sediments	80.7
Schist	76.5
Diorite	71.4
Miscellaneous metamorphics	66.9
Basalt and gabbro	57.1
Pre-Cenozoic marine sediments	51.7
Peridotite and serpentinite	42.9

This list shows that a soil developed upon a Siskiyou quartz diorite will, on the average, be 3.1 times more susceptible to sheet and rill erosion than one developed from serpentinite. When logging on such an area you should be at least 3.1 times more diligent in applying the rules of "logging to preserve water quality."

A rockhound in your crew can probably distinguish all of these rocks when he sees them. If he is confused by a couple of the entries you can help him by telling him that by "Cenozoic Non-Marine" you mean the conglomerates and shales that are found around Weaverville and that by "Pre-Cenozoic Marine Sediments" you mean the coastal and Franciscan graywackies.

If you don't have a rockhound in your crew, maybe you can make one out of a chokersetter. All it would take is a copy of the book by

Travis,[5] a pocket lens, and a little bit of practice

As a last resort, try using another map (fig. 2). This one was produced by solving the equation for the surface-aggregation ratio on the basis of existing small-scale geologic maps. The map will give you a general idea of how the surface soil erodibility varies in different parts of northwest California, but it will not help when you look at some minor intrusion or inclusion of a different type of rock that was too small to show on the geologic map.

5/ Travis, Russell B. Classification of rocks. Quart. Colorado School Mines 50(1): 1-98, 1955. Available from the Colorado School of Mines, Golden, Colorado, $1.00.

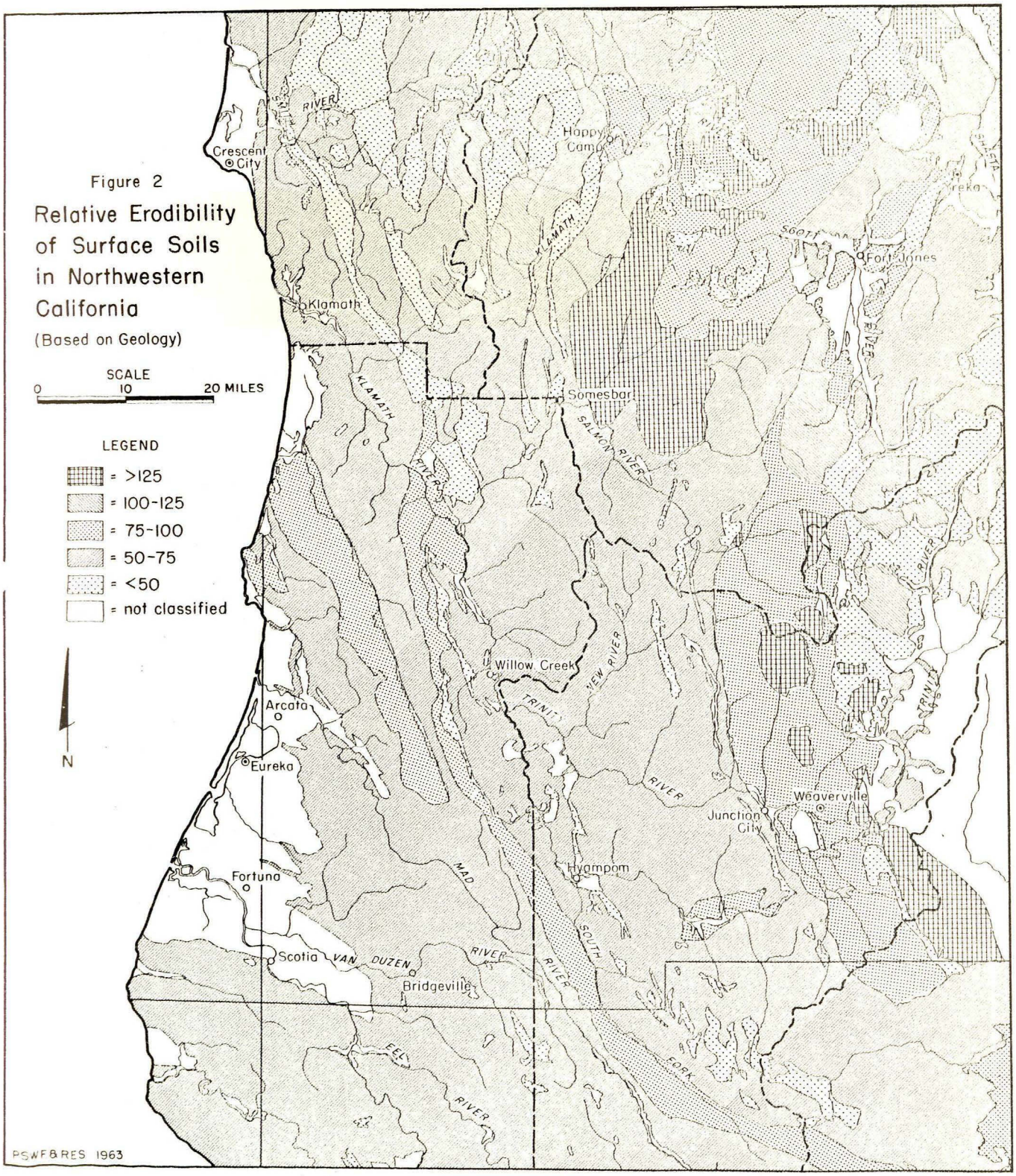
Figure 2
Relative Erodibility of Surface Soils in Northwestern California
(Based on Geology)
SCALE
0 10 20 MILES
LEGEND
= >125
= 100-125
= 75-100
= 50-75
= <50
= not classified
N
Crescent City
Happy Camp
Klamath
Somesbar
Willow Creek
Arcata
Eureka
Fortuna
Scotia
Bridgeville
Hyampom
Weaverville
Junction City
Fort Jones
KLAMATH RIVER
SALMON RIVER
TRINITY RIVER
NEW RIVER
MAD RIVER
VAN DUZEN RIVER
SOUTH FORK
EEL RIVER
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